UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AN EFFECT OF SURFACE ROUGHNESS TO COLOUR SENSOR DETECTION RANGE IN AMBIENT TEMPERATURE

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MASTER OF MANUFACTURING ENGINEERING (INDUSTRIAL ENGINEERING)

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A thesis submitted in fulfilment of the requirements for the degree of Master of Manufacturing Engineering (Industrial Engineering)

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DECLARATION

I declare that this thesis entitled "An Effect of Surface Roughness to Colour Sensor Detection Range in Ambient Temperature" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Industrial Engineering).

Signature : …………..…………..….

Supervisor Name :…………….……………….

Date :………………………….

DEDICATION

To Noor Haniza,

my beloved wife,

whose scarifies care for me and our children

made it possible for me to complete this work,

and to our three sons,

Emir, Haris and Fahri,

who are indeed a treasure from the Lord.

ABSTRACT

An experimental investigation was conducted to explore the effect of surface roughness to colour sensor detection range. The aim of this study is to obtain an acceptable reading level due to colour sensor reading error when there is a difference in surface roughness of the same colour surface. This study uses Arduino Uno microprocessor and is fitted with TCS3200 colour sensor to obtain frequency reading of each ABS plastic colour. The results revealed that the higher the roughness value, the lower the value of the frequency but the higher the colour level will be. The appropriate and acceptable roughness is below 0.38 µm for red coloured plastic red, 0.45 µm for green coloured plastic and 0.35 µm for blue coloured plastic The results presented here may facilitate improvements in the quality of toy manufacture, medical electronic and individuals involved with colour-related studies.

ABSTRAK

Eksperimen ini telah dijalankan untuk meneroka kesan kekasaran permukaan ke atas jarak bacaan sensor warna. Tujuan kajian ini adalah untuk mendapatkan tahap bacaan yang boleh diterima disebabkan oleh ralat sensor warna apabila terdapat perbezaan kekasaran permukaan walaupon warna yang sama. Kajian ini menggunakan mikropemproses Arduino Uno dan dilengkapi dengan sensor warna TCS3200 untuk mendapatkan bacaan frekuensi setiap warna plastik ABS. Hasilnya mendapati bahawa nilai kekasaran yang lebih tinggi membuatkan semakin rendah nilai bacaan frekuensi tetapi semakin tinggi tahap warnanya.

Kekasaran yang sesuai dan boleh diterima adalah di bawah 0.38 μm untuk plastik berwarna merah, 0.45 μm untuk plastik berwarna hijau dan 0.35 μm untuk plastik berwarna biru. Keputusan yang ditunjukkan di sini mungkin boleh meningkatkan kualiti dalam pembuatan mainan, elektronik perubatan dan individu yang terlibat dengan kajian berkaitan warna.

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LIST OF ABBREVIATIONS

ABS	Acrylonitrile Butadiene Styrene
BMS	Building Monitoring System
CFA	Colour Filter Arrays
CMYK	Cyan, Magenta, Yellow, Key(Black)
GLCM	Grey Level Co-occurrence Matrix
IDE	Integrated Development Environment
NASA	National Aeronautics and Space Administration
PFD	Process Flow Diagram
RGB	Red, Green, Blue
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

1.1 Background of study

Light is an electromagnetic wave which comes in various wavelengths. These wavelengths enter the eyes and the vitality get consumed by cells on the back of the eye. The wavelength was measured and calculated within a wide spectral range (Qiankai, 2015). This light energy then changed over into synthetic energy, gets prepared by a couple of hundred million specific neurons, and after a couple portions of a moment, mysteriously the mind says the wavelength of 720nm is red, 450nm is blue and the wavelength of 520nm is green (Lauren et. al., 2018). These are how robot can see and differentiate the colour by using colour sensor.

Colour sensor also known as light sensor can be produced using discrete parts, (for example, photo resistors or photo transistors), or it works in coordinated methods. Along these lines, the colour sensors are getting to be plainly littler, more exact, dependable and moderate. According to Daun et. al., (2018), despite the fact that the patterns of the colour varieties were generally similar, a few degrees of dissimilarities in their intensities should be observed.

There are two types of colour sensor model. The RGB colour model is an added substance colour model in which red, green, and blue light are included in different approaches to replicate an expansive cluster of colours. The principle motivation behind the RGB colour model is for the sensing, representation, and show of pictures in electronic frameworks, for example, televisions and computers. However, it has additionally been utilized as a part of regular photography. Before the electronic age, the RGB colour model as of now had a strong hypothesis behind it, situated in human view of colours. The CMYK colour model (process colour, four colours) is a subtractive colour model, utilized as a part of colour printing, and is likewise used to depict the printing procedure itself. CMYK alludes to the four inks utilized as a part of some colour printing: cyan, magenta, yellow, and key (Black).

A large portion of the colour sensors depend on similar standards, such as on measuring the force of light reflected from a specific surface. Reflected light is distinguished by photo detectors for the most part made in semiconductor innovation. A large portion of the colour that have been identified have a place with a gathering comprising of red, green and blue colour. The surface reflection becomes major influence (Laura et. al., 2016) which every thick of roughness will resulting in the percent of light receives.

1.2 Problem statement

The errors has increased when various roughness occur at product surface while the target was to reduce errors by records the wavelengths and transmit the required task. Colour sensing reflectance is diffused and independent from the angle of view (Javier and Marcelo, 2013). Sensor needs a flat surface (Roxanne et. al., 2016) to produce a better result and Graciele, (2014) stated the colour detection methods are depends on light absorption in different depths. It affect the reading of colours level in toy manufacturing. Therefore, in this investigation, the effect of surface roughness towards colour sensor has been examined.

1.3 Objectives of study

a. To measure the effect of various surface roughness towards range of colour sensor reading.

b. To suggest the finest surface roughness that should be considered in colour detection.

1.4 Scope of study

a. RGB colour sensor TCS3200 being used instead of CMYK colour sensor.

b. ABS Plastics with Ra (µm) 0.2, 0.4 and 0.6 being used as samples.

c. A set of colour namely red, green and blue painted onto cubical ABS plastic to get a various rate of reading.

1.5 Significant of study

This study plays a significant role in widen industries such as displays calibration, printers, textiles, car manufacture, toys production and medical applications such as blood diagnostics, urine analysis, and dental matching. The results of this analysis will give a clear picture of the effectiveness of colour sensors and use it optimally.

1.6 Research Planning

Activity planning of this research is outline in a Gantt chart in Appendix A.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Colour sensors, for the most part, are utilized for two particular applications: true colour recognition and colour mark detection. Sensors utilized for true colour recognition are required to spot distinctive colours or to recognize shades of a particular colour. It can be used in either a sorting or matching mode. Colour mark detection sensors don't recognize the colour of the mark, rather, it recognizes dissimilarities or changes in the mark in contrast with other marks or backgrounds. Surface roughness plays an important role in detecting colour by colour sensor. Smooth surfaces may give different readings than the rough surface and material diversity also impacts directly on the sensor readings. Hence, to optimize the use of a colour sensor, a study should be conducted to identify the level of surface roughness that can affect the colour sensor.

2.2 Wavelength

According to Cambridge Dictionary, colour is the appearance that something has as a result of reflecting light. NASA clarify the visible light is an electromagnetic wave in scope of 400 to 700nm. This is only a little piece of every single existing wavelength. The light that has been see is not one wavelength but rather a blend of numerous wavelengths. Figure 2.1 shows wavelength meter for visible light. Degradation rate and level of staining corresponded well with the light vitality and wavelength (Liu et. al., 2015) cause colour sensors produce results that vary according to the received lighting and light absorbed by the product. These products can come from a variety of materials such as wood, metal, plastic and more.

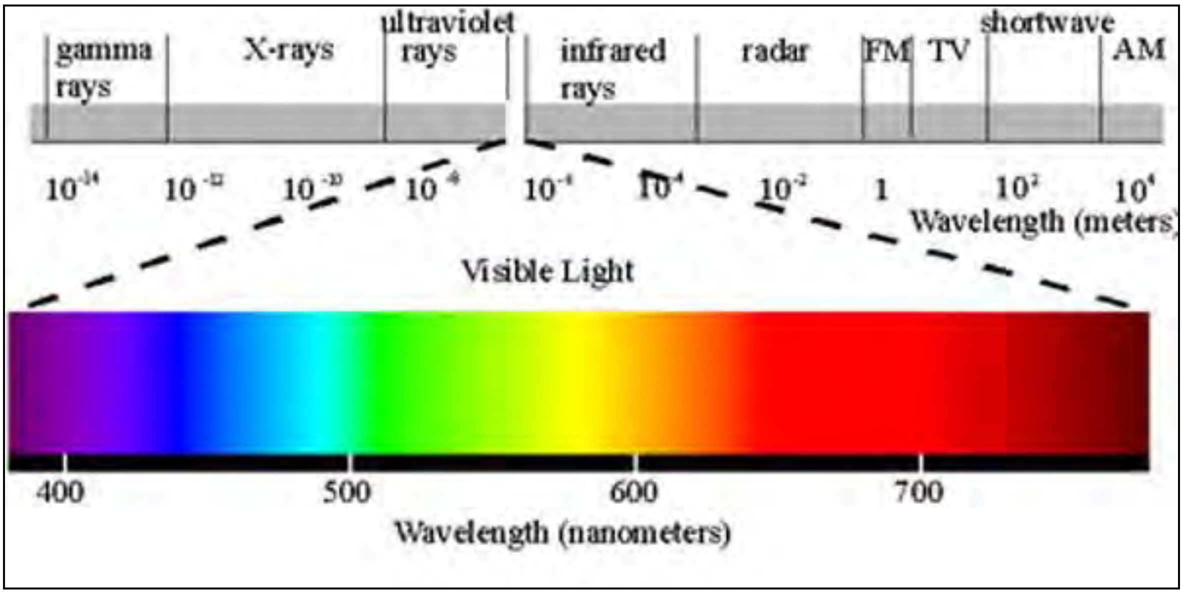

Figure 2.1: Wavelength meter shows the position of visible light (Ruth Netting, 2007)

The wavelength can be calculated by the displacement between two light intensity curve (Xinrong et. al, 2017). In the investigation of wavelength estimation, diversiform strategies and procedures have been advanced to ensure the accuracy and stability (Yan, et. al, 2010). According to Nageshwar and Vora (2007), with various thickness utilized in the wake of acquiring the rough estimation of wavelength it's continually enhance estimation precision. Numerous wavelength measurement methods have been accounted for. They are portrayed by different utilization properties and measuring feasibilities. Choice of the ideal technique relies upon numerous variables. The hugest are the required measuring precision, measuring range, required measuring speed, measuring costs, tested wavelength, intelligibility length of the tested laser, plane wavefront many more (Marek and Mariusz, 2017).

The wavelength and energy of the laser assumed an imperative part in the discovery capacity of the component. The example material is identified with the retention character of laser energy and wavelength. Wang et. al., (2018) expressed that forces of the ghastly powers expanded with the expanding of laser vitality at various wavelengths, and afterward tended to change tenderly. Abhishek and Prabha, (2018) found that expansion in wavelength and amplitude of the wavy fin fundamentally expanded the collector efficiency factor, collector heat removal factor, thermal effectiveness, effective efficiency and ascend in temperature at the lower mass flow rate. A colour sensors configuration exploits the wavelength subordinate absorption properties of silicon has been created where the three essential colours utilized in advanced imaging, red, green and blue are extracted without thin film filtering (Kai et. al., 2017).

As conclusion, the visible spectrum is the segment of the electromagnetic range that is noticeable to the human eye. Electromagnetic radiation in this scope of wavelengths is called visible light. Visible light waves comprise of various wavelengths. The colour of visible light relies upon its wavelength. These wavelengths range from 700 nm at the red of the spectrum to 400 nm at the violet.

2.3 Colour sensor

Colour Sensor is a colour detector that can detect and measure a nearly limitless range of visible colours (Pankaj et. al, 2014) and also colour sensor system can process light reflected from a surface and produce a digital output expressing the colour of the surface (Maher et. al, 2014). The different on surface roughness because of the substance of materials (Shamsul and Rajeev, 2016) will affect the sensor readings (Sazly et. al, 2017). Jong-Sik et. al., (2017) successfully proved the M-13 bacteriophage-based colour sensor permitting of sensitive and selective recognition of antibiotics.

As per light colorimetric hypothesis, a colour measurement requires no less than three spectral independent sensor signals with opponent colour sensitivity to accurately signify to a R(red), G(green), B(blue) or X, Y, Z colour space (Ohta and Robertson, 2005). Preferably the three signals ought to be coordinated to the spectral sensitivity of human eye photoreceptors represented to by the colour matching functions. The R, G, B colour matching functions describe an appropriate mixing of three defined primary colours that matches a single wavelength colour stimulus (Westland and Ripamonti, 2004). The R, G, B colour matching functions were characterized by analyses and perception according the human eye colour observation while the X, Y, Z model was finished by a mathematical model.

Colour sensing in commercial and industrial applications is usually based on Bayer Colour Filter Arrays (CFA) (Bayer, 1976). In CFA's a photo sensor with almost constant light sensitivity over a wide spectral range is used, while the colour sensitivity is provided by filters added on top of the sensor, as shows in figure 2.2. Due to the filters, the overall sensor sensitivity is decreased. Furthermore, CFA's require complex filter assembly on top of the sensor which significantly increases the production costs. One of the studies that has been done using colour sensors is to measure the colour of the soil. The Nix Pro Colour Sensor was repeatable in view of critical positive connections between outputs when contrasting arrangements of dry soil tests and for examines when looking at sets of moist examples. There were critical contrasts in colour for filters for dry versus moist soil tests (Roxanne et. al., 2016) while the colours of soil and adjustment card were gotten and changed over into RGB motions in the meantime. After colour adjustment and filtration, the rapid, successful, and simple soil classification can be acknowledged with the cell phone camera (Pengcheng et. al., 2016).

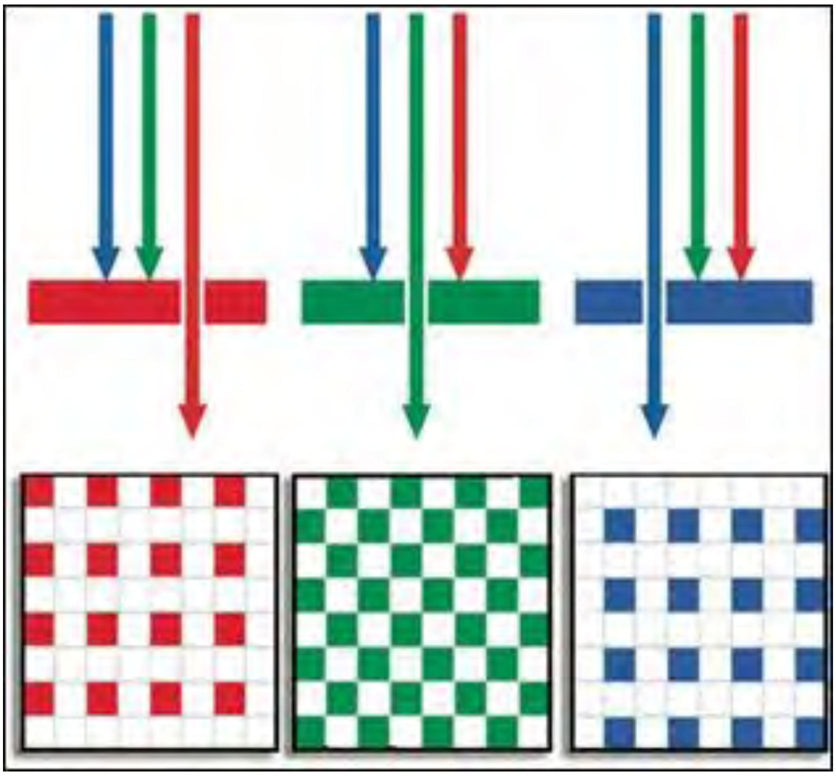

Figure 2.2: Bayer colour filter

On other hand, the reliability of a product (Titu-Marius, 2013) to reflect light to a receiver makes significant impact on the efficiency of the sensor readings (Drago et. al., 2015). Figure 2.3 shows the concept of sensing the colour from sample. Each substance of the material is very different light reflection rate and the smooth surface make better light reflection (Kensei et. al., 2016). Jian, (2017) stated that based on the area of the diffusion areas between the virtual images which are formed by a light source on the surfaces with different roughness levels. Eight standard rough surfaces with roughness values (Ra) of 50 µm, 25 µm, 12.5 µm, 6.3 µm 3.2 µm, 1.6 µm, 0.8 µm, and 0.4 µm were tested in the studied by Zhengkun and Yilei, (2017).